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Amphibian and Reptile Communities in Hardwood Forest and Old Field Habitats in the Central Virginia Piedmont

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ABSTRACT

A 13-month drift fence study in two replicates of hardwood forest stands and two fields in early succession in the central Virginia Piedmont revealed that amphibian abundance is significantly reduced by removal of forest cover. Pitfall traps captured 12 species of frogs, nine salamanders, four lizards, and five snakes. Twenty-two species of amphibians were captured on the hardwood sites compared to 15 species on the old fields. Eight times as many amphibians were caught per trap day on both hardwood sites than in the combined old field sites. The total number of frogs captured on the hardwoods was higher than in the old fields, as was the total number of salamanders. Numbers of frogs and salamanders captured per trap day were significantly higher in the hardwood sites than in the old field sites. Seven species of small-bodied reptiles were caught in both habitat types. More lizard species were captured in the old fields, whereas more snakes were caught in the hardwoods. The number of individual reptiles captured per trap day was similar in both habitat types. Despite the fact that large portions of the Virginia Piedmont remained in agriculture following losses in the 18th century, reclaimed areas such as in private and state forests, state and national parks, and federal military bases have slowed amphibian declines in some of this landscape. Projected urban growth and continued timber harvest in the Virginia Piedmont may substantially reduce amphibian species richness in portions of this region leaving only generalist species.

Key words: Anura, clearcut, forest management, lizard, Piedmont, salamander, snake, Virginia.

INTRODUCTION

A basic tenant in ecology is that animal assemblages contain species distributed unequally within and among habitat types. Such variation is due to such factors as species distribution patterns, annual variation in weather, seasonal variation in environmental conditions such as moisture and pH, microhabitat structure, densities of predators and prey, and natural and anthropogenic changes in habitat structure (e.g., Adler, 1988; Kirkland, 1990; Mitchell et al., 1997; Bellows et al., 2001; Brawn et al., 2001). Species richness (alpha diversity) of amphibian and reptile assemblages may be similar between habitats but the relative abundance of individual species varies (Magurran, 2004). More often than not, both species richness and their relative abundances vary within assemblages among different habitat types (e.g., Ross et al., 2000; Knapp et al., 2003; Goldstein et al., 2005). These relationships have been studied in Virginia for mammals (e.g., Pagels et al., 1992; Mitchell et al., 1997; Bellows et al., 1999, 2001; Bellows & Mitchell, 2000; Shively et al., 2006) and amphibians and reptiles (e.g., Buhlmann et al., 1994; Mitchell et al., 1997; Harpole & Haas, 1999; Mitchell et al., 2000; Burruss et al., 2011).

In 1989 and 1990, I conducted a study of terrestrial amphibians and small reptiles at four localities in northern Cumberland County, Virginia, in connection with a site evaluation for a proposed coal-fired power plant. The habitats in this area differed dramatically. Two of the study sites were hardwood forests with canopy cover, whereas two others had been clearcut and completely lacked canopy cover. In this paper, I report the results of a study comparing the structure of amphibian and squamate (lizard and snake) reptile assemblages in these two contrasting habitat types to ask if the magnitude of the differences between these two habitats in this area may have broader applications in the central Virginia Piedmont physiographic region.

STUDY SITES

I studied the herpetofaunas on four sites in Cumberland County, Virginia, from 7 September 1989 to 30 September 1990. The sites were selected to represent the most common habitats in this region that were not in active agriculture. Site locations were non-randomly selected for road access and visual representation of the habitat. Their locations were roughly along a line extending 3-6 km south of the town of Columbia in Goochland County (Fig. 1). The study sites included two separate mixed hardwood stands (designated as north [HW-N] and south [HW-S], both approximately 40+ yr in age) and two areas that had been previously clearcut (fields in early succession [= old fields], also north [OF-N] and south [OF-S]) that were 3 yr and 6 yr old, respectively. Descriptions of the study sites (Fig. 2) are derived from Pagels et al. (1992), Erdle (1997), and my own observations.

Hardwood stands - The most abundant tree species in HW-N were red maple (*Acer rubra*), shortleaf pine (*Pinus echinata*), tulip poplar (*Liriodendron tulipifera*), American beech (*Fagus grandifolia*), and white oak (*Quercus alba*). The sparse understory consisted primarily of dogwood (*Cornus virginianus*). Canopy cover averaged 86%. A tributary of Cobb Creek was located adjacent to this site. HW-S differed from HW-N in the relative abundance of trees and the composition of the herbaceous layer. Sweet gum (*Liquidambar styraciflua*) was the most abundant tree species, followed by tulip poplar, red maple, and white oak. Canopy cover was 75%. A tributary of Johnson's Creek was about 20 m away from this site.

Old fields - OF-N was characterized primarily by shrubs such as gooseberry (*Ribes* spp.) and blueberry (*Vaccinium* spp.) followed by forbs and vines. OF-S consisted primarily of forbs, such as horse weed (*Erigeron canadensis*), white thoroughwort (*Eupatorium album*), partridge berry (*Mitchella repens*), and partridge pea (*Chamaecrista fasciculata*) followed by vines and grasses. Numerous loblolly pine (*Pinus taeda*) trees had been planted in both sites (Fig. 2). Hardwood stumps occurred on both sites. There was no canopy cover. A very narrow, small seepage area that held water only during wet periods was located within 30–40 m of each site.

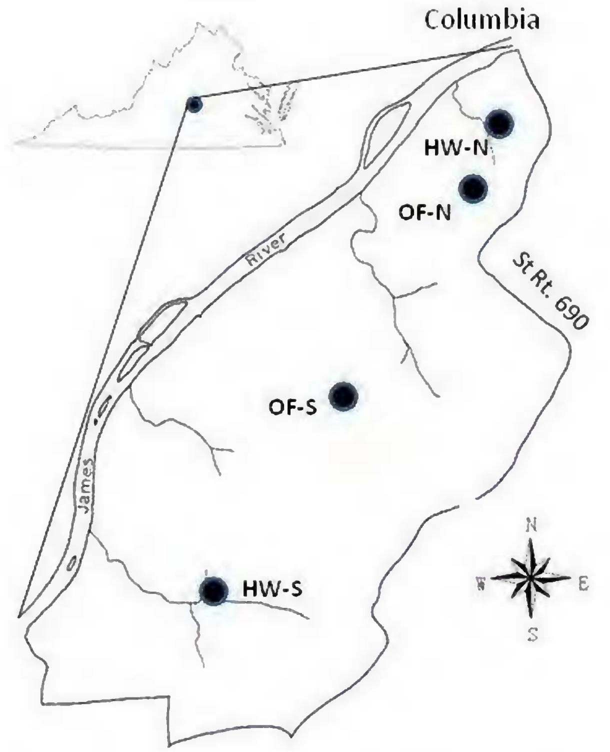

Fig. 1. Location of the five study sites in Cumberland County, Virginia. Abbreviations: HW-N = hardwoods north, HW-S = hardwoods south, OF-N = old field north, OF-S = old field south.

MATERIALS AND METHODS

I used a single pitfall-drift fence array (Campbell & Christman, 1982) in each of the four sites to capture terrestrial amphibians and reptiles. Each array consisted of three 8-m long strips of 60 cm high aluminum flashing set upright in an exploded Y-configuration with each arm located about 7–8 m from the open center of the sample site. A plastic 5-gallon (19-l) bucket was buried flush in the ground at the end of each arm; six pitfall traps in each array. Arrays were set at least 100 m from the nearest edge of the adjacent habitat. Traps contained a weak formalin solution, and were emptied at about two-week intervals. Use of funnel traps placed alongside the drift fences would have increased reptile captures, especially snakes (Vogt & Hine, 1982) but daily trap checks were cost prohibitive. The sampling technique in this study allowed me to effectively compare abundance and species composition of anurans, lizards, and small snakes between the two habitat types

Gender of the adults of each species and juvenile snakes was determined by examination of external morphology. Chi-square tests used herein include Yates correction for continuity following Zar (2009).

Fig. 2. Photographs of the four sampling sites in Cumberland County. Upper left: HW-N, upper right: HW-S, lower left: OF-N, lower right: OF-S. See text for site descriptions.

RESULTS

The drift fence arrays captured 958 individuals in the four study sites during the 13-month study, including 21 species of amphibians and nine species of reptiles (Table 1). Eight times more amphibians (854) were caught than reptiles (104). Seven times as many amphibians were caught per trap day on the hardwood sites than on the old field sites. The number of reptiles captured per trap day was similar in both habitat types (Table 1).

I caught 12 species of frogs and nine species of salamanders in the hardwood sites as compared to nine species of frogs and seven species of salamanders on the old fields. The difference in total number of frog species in hardwoods versus old fields was not significant (X^2 = 0.018, P > 0.75) nor were the comparable values for salamanders (X^2 = 0.062, P > 0.75). The difference in total number of frog and salamander species combined (Table 1) between hardwoods and old fields was not significant (X^2 = 0.432, P > 0.5).

The total number of frogs captured on the hardwoods was higher than in the old fields, as was the total number of salamanders between these two sites (Table 1). Number of frogs captured per trap day between the two habitat types was significantly different (X^2= 3.2, P > 0.05), but not the number of salamanders (X^2 = 0.77, P > 0.25). The number of frogs and salamanders combined that were caught per trap day was significantly higher in hardwoods than in old fields (Table 1, X^2 = 7.87, P < 0.01). Three times as many juvenile frogs (485) were captured than adults (182) and 3.5 times more adult salamanders (146) were captured than juveniles (42). More adult female frogs were caught than adult males in both habitat types. More female salamanders were captured in the hardwoods, but more males were caught in the old fields.

Four species of frogs dominated the anuran fauna in the hardwood sites, *A. americanus*, *L. clamitans*, *L. palustris*, and *L. sylvaticus*. The number per trap day for all of these species did not differ significantly between HW-N and HW-S (P > 0.5 – 0.75). The number of *A. americanus* (P > 0.5) and *L. clamitans* (P > 0.25) captured per trap day did not differ between hardwood and old field sites. Significantly more *A. opacum* were caught in HW-N (63) than in HW-S (5) (X^2 = 6.97, P < 0.025) but not *E. cirrigera* (P > 0.75). *Ambystoma maculatum*, *D. fuscus*, *H. scutatum*, *P. cinereus*, and *P. ruber* were captured only in HW-N.

I caught all four species of lizards in the old fields but only two of these species in the hardwood sites. Five species of small snakes were caught in the hardwoods compared to three species in the old fields (Table 1). The number of lizards captured per trap day

Table 1. Amphibian and squamate reptile species richness in two replicates of deciduous hardwood (HW N&S) and old field (OF N&S) habitats in Cumberland County, Virginia. Trap days were 2,346 in each HW site and 2,190 in each OF site. Numbers for each sample site are males: females: juveniles.

Species	HW-N	HW-S	Total HW	OF-N	OF-S	Total OF
Amphibians						
Anurans						
Acris crepitans[1]	0:2:1	--	3	--	--	0
Anaxyrus americanus	12:50	3:15:36	116	1:5:21	0:3:5	35
Anaxyrus fowleri	--	0:1:9	10	--	--	0
Hyla chrysoscelis	0:1:0	1:1:0	3	--	--	0
Gastrophryne carolinensis	1:0:0	1:3:0	5	0:1:0	0:1:0	2
Lithobates catesbeianus	0:0:3	0:0:1	4	0:0:3	--	3
Lithobates clamitans	5:12:33	11:11:83	155	1:1:6	0:0:2	10
Lithobates palustris	3:4:88	4:14:36	149	0:0:3	0:0:2	5
Lithobates sylvaticus	0:5:50	9:3:46	113	0:8:0	--	8
Pseudacris crucifer	1:2:0	1:8:2	14	2:3:0	1:1:0	7
Pseudacris feriarum	0:1:1	1:8:2	13	2:3:0	1:1:0	7
Scaphiopus holbrookii	0:0:2	0:1:0	3	--	0:1:0	1
Total number of species	11	11	12	8	7	9
Totals by sex	10:39:228	31:65:215	42:104:443	6:21:33	2:7:9	8:28:42
Total individuals	277	311	588	60	18	78
Number per trap day x 100	11.8	13.2	12.5	2.7	0.8	1.9
Salamanders						
Ambystoma maculatum	0:1:4	--	5	1:0:0	0:0:1	2
Ambystoma opacum	18:29:16	1:4:0	68	1:1:2	--	4
Desmognathus fuscus	4:0:0	--	4	--	--	0
Eurycea cirrigera	13:21:3	4:4:0	45	--	2:0:0	2
Hemidactylium scutatum	1:0:0	--	1	--	--	0
Plethodon cinereus	6:11:4	--	21	6:2:0	--	8
Plethodon cylindraceus	2:0:1	2:1:1	7	1:0:0	--	1
Pseudotriton ruber	7:0:0	--	7	3:0:0	--	3
Notophthalmus viridescens	0:0:3	0:0:4	7	0:0:3	--	3
Total number of species	9	4	9	6	2	7
Total by sex	51:62:31	7:9:5	58:71:36	12:3:5	2:0:1	14:3:6
Total individuals	144	21	165	20	3	23
Number per trap day x100	6.1	1.1	3.5	0.9	0.1	0.7
Total amphibians	421	332	753	80	21	101
Number per trap day x100	17.9	14.2	16.0	3.7	1.0	2.3

Table 1. (continued)

Species	HW-N	HW-S	Total HW	OF-N	OF-S	Total OF
Reptiles						
Lizards						
Plestiodon fasciatus	1:0:1	2:1:1	6	0:2:0	1:0:0	3
Plestiodon inexpectatus	--	--	0	--	0:1:0	1
Sceloporus undulatus	0:1:0	3:0:4	8	5:0:6	3:1:2	17
Scincella lateralis	--	--	0	2:4:0	1:2:1	10
Total by sex	1:1:1	5:1:5	6:2:6	7:6:6	5:4:3	12:10:9
Total individuals	3	11	14	19	12	31
Number per trap day x100	0.1	0.4	0.3	0.9	0.5	0.7
Snakes						
Carphophis amoenus	10:1:0	11:6:0	28	5:3:0	2:0:0	10
Diadophis punctatus	0:0:1	3:0:0	4	--	--	0
Storeria dekayi	1:1:0	2:2:0	6	3:1:0	--	4
Storeria occipitomaculata	0:1:0	--	1	0:4:0	0:0:1	5
Thamnophis sirtalis	--	0:0:1	1	--	--	0
Total number of species	6	5	7	6	6	7
Total by sex	11:3:1	16:8:1	27:11:2	8:8:0	2:0:1	10:8:1
Total individuals	15	25	40	16	3	19
Number per trap day x100	0.6	1.1	0.9	0.7	0.1	0.4
Total reptiles	18	36	54	35	15	50
Number per trap day x100	0.8	1.5	1.2	1.6	0.7	1.1

[1]Subsequent to this study, one of the three cricket frogs (*Acris*) caught was identified as a Southern Cricket Frog (*A. gryllus*) by Micancin et al. (2012) using multivariate morphometric analysis. I do not include this species because the location is well outside its known range (Mitchell & Reay, 1999). Identifying preserved specimens with this technique needs verification before acceptance of the results of Micancin et al. (2012).

in the hardwood sites was not significantly different from the number captured per trap day in the old field sites (X^2 = 1.96, P > 0.1). The number of snakes captured per trap day in these two habitat types was also not significantly different (X^2 = 1.54, P > 0.1). There was no obvious pattern for the frequencies of the sex and age groups for lizards. Male snakes were more numerous than females; only three juveniles were captured. I caught more than twice as many snakes in the hardwoods than in the old field sites; the difference is similar for captures per trap day (Table 1). The number of Eastern Wormsnakes (*Carphophis amoenus*) caught per trap day in both habitat types was not significantly different (X^2 = 0.245, P > 0.5).

DISCUSSION

Daytime visual searches of all habitats available, dipnet sampling of pools and streams, and nighttime road surveys, in addition to the drift fence arrays, provided an assessment of the herpetofauna in this part of the Piedmont. All techniques combined provided occurrence data for 92% of the expected number of amphibian species (93% anurans, 91% salamanders) and 60% of the expected number of squamate reptiles (57% lizards, 61% snakes) based on the range maps in Mitchell & Reay (1999) and Beane et al. (2010). The corresponding number of species documented with the drift fence arrays alone was 84% for amphibians (86% anurans, 82% salamanders) and 36% for reptiles (57% lizards, 28% snakes). This single technique provided a robust estimate of amphibian species richness in the central Virginia Piedmont but an incomplete estimate for squamate reptiles. Most of the frogs are either terrestrial or, if primarily arboreal, occur on the ground occasionally (Dorcas & Gibbons, 2008; Dodd, 2013). Treefrogs were undoubtedly underestimated. All of the salamanders captured are terrestrial or semi-aquatic species that often occur terrestrially during part of their life cycles (Petranka, 1998; Mitchell & Gibbons, 2010). Except for *Scincella lateralis*, the lizards are arboreal but occasionally move among habitat patches or forage on the ground (Gibbons et al., 2009). Snakes are notoriously secretive (Gibbons & Dorcas, 2005) and pitfalls capture only small-bodied species. Thus, the results of my assessment of the amphibian fauna in the two contrasting habitats using a pitfall trapping technique allowed for a reasonable inference about the effect of hardwood removal on this group of vertebrates in the Piedmont.

Frog and salamander species richness in hardwoods and old fields was not significantly different, although more species of both groups were found in the hardwood sites. There were significantly more individual amphibians, however, in hardwood habitats than in the old fields. Clearcutting dramatically alters forest structure by removal of the canopy and exposes the substrate to more sunlight and wind creating a much warmer and drier microclimate (Semlitsch et al., 2009). These changes lead to rapid water loss and high mortality in amphibians (Rothermel & Luhring, 2005; Rittenhouse et al., 2008). Sublethal effects include reduced activity and growth (Todd & Rothermel, 2006). Clearcuts are often avoided by juveniles dispersing from aquatic breeding sites (Patrick et al., 2006). The anurans caught in old fields were likely dispersing individuals because these sites lacked aquatic breeding habitats. Salamanders included few dispersing adults and juveniles (e.g., Spotted Salamander [*Ambystoma maculatum*], Red-spotted Newt [*Notophthalmus viridescens*]). Occurrence of streamside species (e.g., *Desmognathus fuscus*, *Pseudotriton ruber*) in old field sites was due to the presence of a small seepage within 30–40 m of both trap arrays, suggesting that water is more important to amphibians than canopy cover. Except for the small creek, there was no water available for breeding amphibians near HW-S, however, the large number of the ephemeral pool-breeding Marbled Salamander (*Ambystoma opacum*) suggests that at least one of these wetlands was within dispersal distance. Adult and juvenile *A. maculatum* and Wood Frogs (*Lithobates sylvaticus*) dispersed from several road-rut pools about 80 m from HW-N.

Kapfer & Munoz (2012) studied amphibians, reptiles, and small mammals in the North Carolina Piedmont during 2010-2011 using a variety of techniques, including drift fence arrays with a single pitfall trap in the center of the X-shaped array and funnel and box traps alongside the fences. Nine species of frogs and four species of salamanders were captured in the hardwood sites but none in their grassland (= old field) sites. Two lizard species were caught in hardwoods and one in grasslands. Six species of snakes were caught in each of the habitat types. Their results support my conclusion that converting hardwoods to early successional habitat causes significant decline in amphibian populations in the Piedmont.

The drift fence design in this study did not capture many reptiles. The higher number of individuals caught in the old fields was not unexpected due to the heliothermic affinities of most species of the lizards that occur in Virginia. Most of the lizards caught in the hardwoods were in HW-S, the site with the lowest amount of canopy cover. The sample size of one small species of snake allowed for statistical testing. More individuals of *C. amoenus* were captured in the hardwood sites than in the old fields. These snakes are most often captured in forested and wooded habitats where the relatively moist soil allows burrowing (Mitchell, 1994). The few captures of the other snake species reveal no patterns and statistical testing was not possible.

The effects of clear-cutting hardwood forests and conversion to early successional fields and managed pine plantations on amphibian species richness and diversity are well known (e.g., Keenan & Kimmins, 1993; Grialou et al., 2000; Todd & Andrews, 2008; Semlitsch et al., 2009). All such conversions have contributed to the ongoing decline of amphibian populations in Virginia, the United States, and elsewhere (Mitchell et al., 1999; Stuart et al., 2004; Adams et al., 2013). Hardwood forests in the Virginia Piedmont were reduced dramatically due to agriculture and timber harvest in the 1600s and 1700s. However, forest regrowth in the first half of the 1900s, largely due to abandonment of farmland (Trani et al., 2001), probably allowed expansion of amphibian populations in areas that reached hardwood forest stages through ecological succession.

Despite the fact that large portions of the Virginia Piedmont have remained in agriculture following losses in the 18th century, reclaimed areas such as in private and state forests, state and national parks, and federal military bases have slowed declines in species richness across some of this landscape (e.g., Mitchell & Roble, 1998; Mitchell, 2006, 2007). Intensive harvesting of hardwood forests in the late 1900s and early 2000s for commercial products, however, again converted large areas to early successional stages or these areas were planted with fast growing pine trees (Conner & Hartsell, 2002; Van Lear et al., 2004). Terrestrial amphibian communities in the Piedmont will continue to be fragmented and their habitats reduced to smaller and smaller patches as long as hardwood deforestation continues (Griep & Collins, 2013). Substantial urban growth in the Piedmont may substantially reduce amphibian species richness in this region, leaving only generalist species. As projected for urban areas (McKinney & Lockwood, 1999; McKinney, 2006), future amphibian communities in much of the Virginia Piedmont may be comprised of only habitat generalists consisting of species such as American Bullfrog (*Lithobates catesbeianus*), Green Frog (*L. clamitans*), American Toad (*Anaxyrus americanus*), Fowler's Toad (*A. fowleri*), Cope's Gray Treefrog (*Hyla chrysoscelis*), Gray Treefrog (*H. versicolor*), and Spring Peeper (*Pseudacris crucifer*). Amphibian community homogenization may be the future for much of the central Virginia Piedmont except in protected areas with the remaining mature hardwoods.

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